Intelligent Waste Management for Smart Cities

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ABSTRACT:

The ever-growing Internet of Things has enabled objects to be uniquely identified and made to communicate with each other. This approach has been applied to dustbins too, to monitor garbage collection, throwing light on numerous valuable insights. Our project too employs a similar approach, to not only monitor garbage collection but also optimize it, using machine learning. The method of unsupervised learning we utilize is K Means Clustering, widely used in data mining and analytics. Our physical device uses an ultrasonic sensor to be aware of a dustbin's current content level. If the level reaches or exceeds a threshold percentage of the total capacity of the dustbin, it inform our servers, via an online application programming interface (API) developed for this purpose. The API also stores the related data – fill time, cleanup time, and location, to name a few. This dynamic dataset generated is analyzed by our algorithm, to determine the times of the day, when a regular cleanup should be performed, such that the dustbins are clean, for the maximum possible portion of the day. The algorithm also shows the locations, where another dustbin should be installed, for further optimization. A new dustbin installation is advised at such locations. Data henceforth generated revealed that the installation has had a positive effect on the optimization.

KEYWORDS: K Means Clustering, analytics, threshold, API, optimization, ThingSpeak

INTRODUCTION:

Waste management or waste disposals are all the activities and actions required to manage waste from its inception to its final disposal. This includes amongst other things collection, transport, treatment and disposal of waste together with monitoring and regulation. It also encompasses the legal and regulatory framework that relates to waste management encompassing guidance on recycling. Waste can take any form that is solid, liquid, or gas and each have different methods of disposal and management [1]. Waste management normally deals with all types of waste whether it was created in forms that are industrial, biological, household, and special cases where it may pose a threat to human health. It is produced due to human activity such as when factories extract and process raw materials. Waste management is intended to reduce adverse effects of waste on health, environment or aesthetics. Waste management practices are not uniform among countries regions (urban or rural areas), and sectors. A large portion of waste management practices deal with municipal solid waste (MSW) which is waste that is created by household, industrial, and commercial activity [9].Curbside collection the most common method of disposal in most European countries, Canada, New Zealand and many other parts of the developed world in which waste is collected at regular intervals by specialized trucks. This is often associated with curb-side waste segregation. In rural areas waste may need to be taken to a transfer station. Waste collected is then transported to an appropriate 2 disposal facility. In some areas, vacuum collection is used in which waste is transported from the home or commercial premises by vacuum along small bore tubes. Systems are in use in Europe and North America [2].

In some jurisdictions unsegregated waste is collected at the curb-side or from waste transfer stations and then sorted into recyclables and unusable waste. Such systems are capable of

sorting large volumes of solid waste, salvaging recyclables, and turning the rest into bio-gas and soil conditioner [11]. In San Francisco, the local government established its Mandatory Recycling and Composting Ordinance in support of its goal of "Zero waste by 2020", requiring everyone in the city to keep recyclables and compostables out of the landfill.

The three streams are collected with the curbside "Fantastic 3" bin system – blue for recyclables, green for compostables, and black for landfill-bound materials – provided to residents and businesses and serviced by San Francisco's sole refuse hauler, recology. The City's "Pay-As-You-Throw" system charges customers by the volume of landfill-bound materials, which provides a financial incentive to separate recyclables and compostables from other discards. The City's Department of the Environment's Zero Waste Program has led the City to achieve 80% diversion, the highest diversion rate in North America. Other businesses such as Waste Industries use a variety of colors to distinguish between trash and recycling cans.

An important method of waste management is the prevention of waste material being created, also known as waste reduction. Methods of avoidance include reuse of second-hand products, repairing broken items instead of buying new, designing products to be refillable or reusable (such as cotton instead of 3 plastic shopping bags), encouraging consumers to avoid using disposable products, removing any food/liquid remains from cans and packaging, and designing products that use less material to achieve the same purpose (for example, light weighting of beverage cans) [3].

Waste is not something that should be discarded or disposed of with no regard for future use. It can be a valuable resource if addressed correctly, through policy and practice. With rational and consistent waste management practices there is an opportunity to reap a range of benefits. Those benefits include:

1. Economic – Improving economic efficiency through the means of resource use, treatment and disposal and creating markets for recycles can lead to efficient practices in the production and consumption of products and materials resulting in valuable materials being recovered for reuse and the potential for new jobs and new business opportunities.

2. Social – By reducing adverse impacts on health by proper waste management practices, the resulting consequences are more appealing settlements. Better social advantages can lead to new sources of employment and potentially lifting communities out of poverty especially in some of the developing poorer countries and cities.

3.Environmental – Reducing or eliminating adverse impacts on the environment through reducing, reusing and recycling, and minimizing resource extraction can provide improved air and water quality and help in the reduction of greenhouse gas emissions.

4. Inter-generational Equity – Following effective waste management practices can provide subsequent generations a more robust economy, a fairer and more inclusive society and a cleaner environment.

Waste management in cities with developing economies in transition experience exhausted waste collection services and inadequately managed and uncontrolled dumpsites. The problems are worsening. Problems with governance complicate the situation. Waste management, in these countries and cities, is an ongoing challenge and many struggles due to weak institutions, chronic under-resourcing and rapid urbanization. All of these challenges, along with the lack of understanding of different factors that contribute to the hierarchy of waste management, affect the treatment of waste [6].

LITERATURE REVIEW

In 2016, S.S. Navghane, et.al [9] designed a system in which the dustbins are interfaced with microcontroller based system having IR wireless systems along with central system

showing current status of garbage, on mobile web browser with html page by Wi-Fi. Hence the status will be updated on to the html page. Major part of our project depends upon the working of the Wi-Fi module; essential for its implementation. The main aim of this project is to reduce human resources and efforts along with the enhancement of a smart city vision. The IR sensors will show us the various levels of garbage in the dustbins and also the weight sensor gets activated to send its output ahead when its threshold level is crossed. These details are further given of the microcontroller (ARM LPC2148) and the controller gives the details to the transmitter module (Wi-Fi module). At the receiver section a mobile handset is needed to be connected to the Wi-Fi router so the details of the garbage bins is displayed onto the HTML page in the web browser of our mobile handset.

In 2016, Dr. N. Sathish Kumar, et.al [10] developed a smart intelligent garbage alert system for a proper garbage management. This paper proposes a smart alert 6 system for garbage clearance by giving an alert signal to the municipal web server for instant cleaning of dustbin with proper verification based on level of garbage filling. This process is aided by the ultrasonic sensor which is interfaced with Arduino UNO to check the level of garbage filled in the dustbin and sends the alert to the municipal web server once if garbage is filled. After cleaning the dustbin, the driver confirms the task of emptying the garbage with the aid of RFID Tag. RFID is a computing technology that is used for verification process and in addition, it also enhances the smart garbage alert system by providing automatic identification of garbage filled in the dustbin and sends the status of clean-up to the server affirming that the work is done. The whole process is upheld by an embedded module integrated with RF ID and IOT Facilitation. The real time status of how waste collection is being done could be monitored and followed up by the municipality authority with the aid of this system. In addition to this the necessary remedial / alternate measures could be adapted. An Android application is developed and linked to a web server to intimate the alerts from the microcontroller to the urban office and to perform the remote monitoring of the cleaning process, done by the workers, thereby reducing the manual process of monitoring and verification. The notifications are sent to the Android application using Wi-Fi module.

In 2015, Gaikwad Prajakta, et.al [3] developed an Automatic garbage collection and information gathering system which is based on Image processing as well as on GSM module. The main concept is that a Camera will be placed at every garbage collection point along with load cell sensor at bottom of the garbage can. The camera will take continuous snapshots of the garbage can. A threshold level is set which compares the output of camera and load sensor. The comparison is done with help of microcontroller. After analyzing the image we get an idea about level of garbage in the can and from the load cell sensor we get to know weight of garbage. Accordingly information is processed that is controller checks if the threshold level is exceeded or not. The controller sends a message with the help of GSM module to Garbage collection local central office to notify that garbage can is exceeded its capacity and disposal of waste is required. Accordingly the authority sends the garbage can collecting vehicle to collect the garbage, which is done with the help of robot mechanism.

In 2014, Abd Wahab, et.al [8] proposed a smart recycle bin application based on information in the smart card to automatically calculate the weight of waste and convert the weight into point then store it into the card. The wastes are tracked by smart bins using a RFID-based system integrating the web-based information system at the host server. Two crucial features of the selective sorting process can be improved using this approach. First, the user is assisted in the application of material waste classification. Second, the smart bin knows its content and can report back to the rest of the recycling chain. In ensuring that the desired goals of the recycling program are achieved, an effective implementation of the 3R (reduces, reuse, recycle) concepts and practices in solid waste management is therefore crucial. Efforts to promote the 3R (reduce, reuse and recycle) program are increasing to encourage the reduction of waste going into landfills for protecting and conserving natural resources, environment and energy.

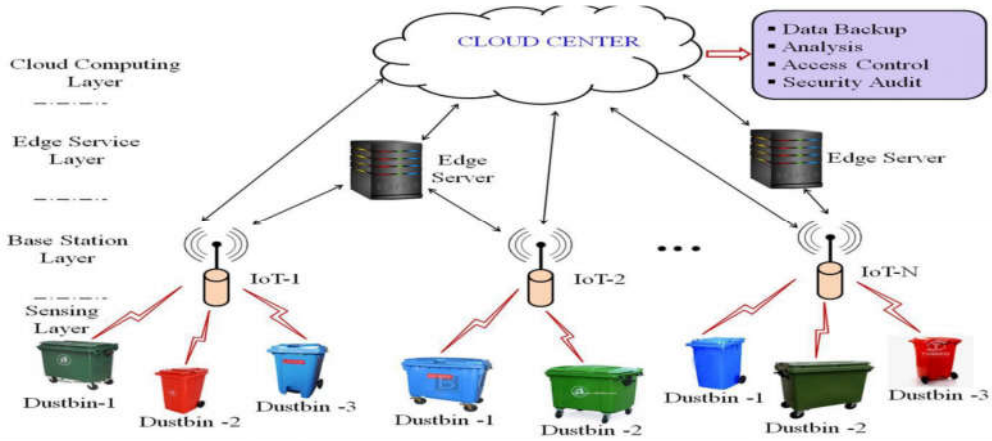


FIG.1 ARCHITECTURE OF THE PROPOSED SYSTEM

The controller initializes the sensor, Wi-Fi and always checks the level of the signal. It will compare the received signal (TL) from the sensor and compared with the look-up table values (LTHD). Based on the signal received from the sensor, the corresponding status of the dustbin such as empty dust bin, half filled and dustbin full are updated in the database. Here we have used Local web server to demonstrate the working of this Garbage Monitoring System.

BLOCK DIAGRAM:

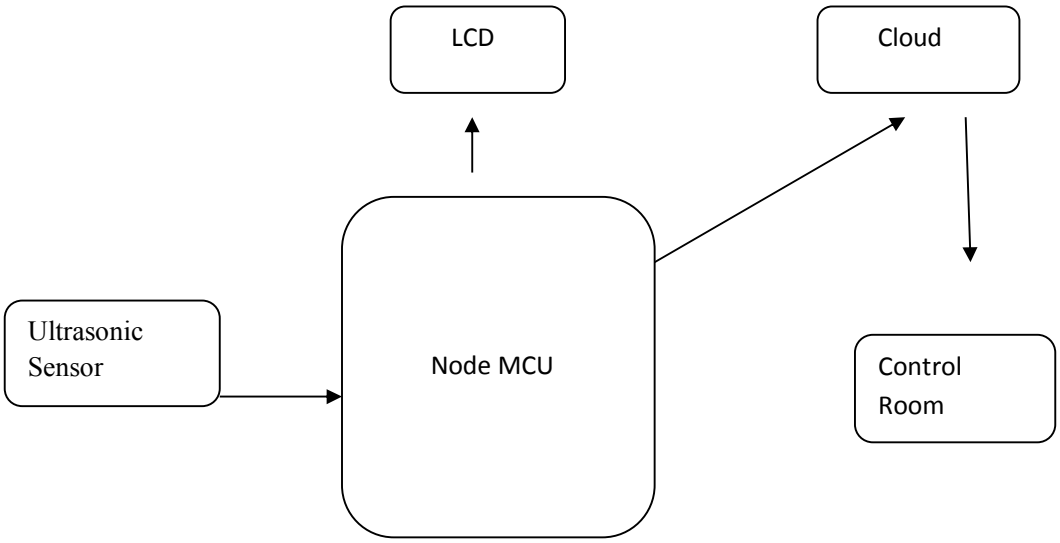


FIG.2 BLOCK DIAGRAM OF THE SYSTEM

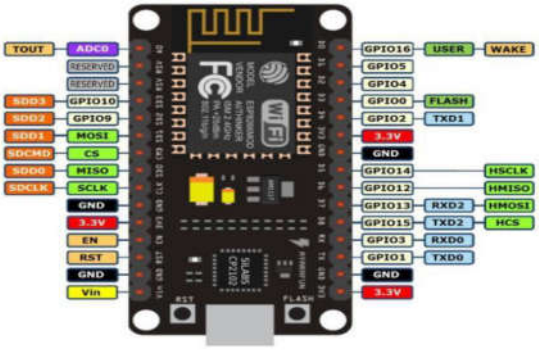
Here Ultrasonic Sensor is installed at the top of Trash Can and will measure the distance of garbage from the top of Trash can and we can set a threshold value according to the size of trash can. If the distance will be less than this threshold value, means that the Trash can is full of garbage and we will print the message “Dustbin is Full” on the webpage and if the distance will be more than this threshold value, then we will print the message “Dustbin is

Empty". We will use node MCU Wi-Fi module to connect to the web server. Here we have used Local web server to demonstrate the working of this Garbage Monitoring System.

HARDWARE USED:

- Developer - ESP8266 open source community
- Type - single-board microcontroller
- Operating - system XTOS
- CPU - ESP8266 (LX106)
- Memory - 128k bytes
- Storage - 4Mbytes
- Power - USB

FIG.3 NODE MCU



Nodemcu dev kit	ESP8266 Pin	Nodemcu dev kit	ESP8266 Pin
D0	GPIO16	D7	GPIO13
D1	GPIO5	D8	GPIO15
D2	GPIO4	D9	GPIO3
D3	GPIO0	D10	GPIO1
D4	GPIO2	D11	GPIO9
D5	GPIO14	D12	GPIO10
D6	GPIO12		

FIG. 3.1 PIN DESCRIPTION OF NODE MCU **TABLE 3.2 GPIO PINS**

Table 3.2 displays the general purpose input/output pins of Node MCU module. There are twelve digital pins in Node MCU. Each digital pin has a predefined constant value.

ULTRASONIC SENSOR

The ultrasonic sensor uses sound to determine the distance between the sensor and the object positioned. This operates at a frequency higher than the human frequency.

FIG. 4 ULTRASONIC SENSOR

SPECIFICATIONS:

- Ranging Distance: 2•400 cm
- Resolution: 0.3 cm
- Measuring Angle: 30º
- Trigger Input Pulse width: 10uS
- Dimension: 45mm x 20mm x 15mm
- Weight: approx. 10

FIG.5 LIQUID CRYSTAL DISPLAY

The liquid crystal displays are used to visualize the output produced finally. It displays the various states of the work if the bins are filled, half filled or empty to take the necessary action by the corresponding people.

SOFTWARE REQUIREMENTS:

THINGSPEAK

ThingSpeak is an open IoT platform which lets the user to analyze, visualize live data in cloud. It also allows perform online analysis and processing of data. ThingSpeak is widely used as a proof for IoT systems where analytics are required. It is utilized to store and recover the data from things with HTTP convention over internet. It has certain key features like

- Visualizing the sensor data in real
- Easy configurability
- Automatic action on data and communication through third party services
- Functions on schedules or events

ORIGIN:

Written in - Ruby

Operation system - cross platform

Available in – English, Italian, Brazilian, Portugese

Type - API

License - GPL version 3

ARDUINO IDE:

A program can be written with the help of compilers in Arduino which will produce binary message code for the processor. It is generally used to program UNO and Node MCU boards.

IDE stands for integrated development environment which serves as a cross platform application to program using Java. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures.

ORIGIN:

1. Developers - Arduino Software
2. Stable Release - 1.85/29 September 2017, 6 months ago
3. Repository - https://github.com/arduino/Arduino
4. Written in - Java , C, C++
5. Operating system - Windows, macOS, Linux
6. Platform - IA-32, X86-64, ARM

FLOW CHART:

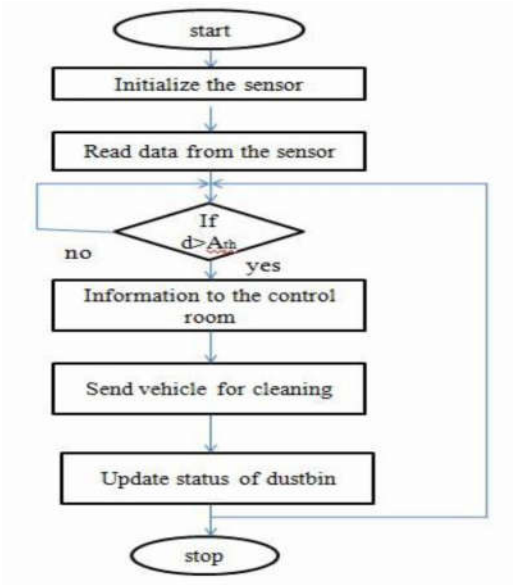


FIG.6 FLOW DIAGRAM OF THE SYSTEM

The flowchart shows the working of our proposed garbage management system from initialization of sensor, comparing the sensor value with threshold value, updating to the cloud and taking necessary steps for cleaning.

RESULTS:

FIG. 7.1 LCD OUTPUT

FIG. 7.2 LCD OUTPUT

FIG.7.3 LCD OUTPUT

This is the LCD output with the read sensor value it is compared with the threshold value which is given in the loop. In case (I), the particular string "**Bin is empty**" is displayed (Fig. 7.1) for any distance value above 70cmssince the condition is given as **distance>70** in the loop.

In case (ii), the particular string "**Bin is filled**" is displayed (Fig. 7.2). The condition is given as **distance<= 15** in the loop. When this condition is achieved alert is given to the concerned persons for cleaning. The alert is given by the person in the control room.

In case (iii), the particular string "**Partially filled**" is displayed (Fig. 7.3). The condition is given as **distance >15 && distance <= 35** in the loop.

SERIAL MONITOR OUTPUT

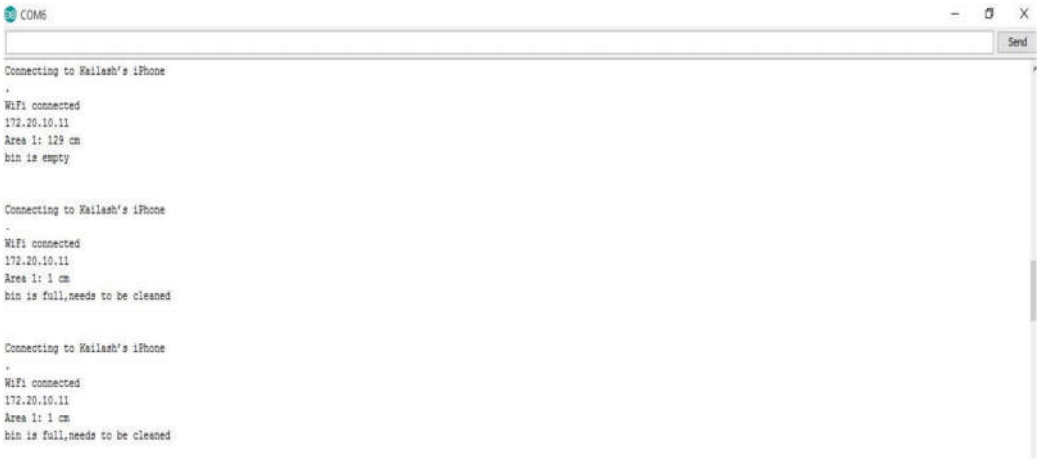


FIG.8 OUTPUT DISPLAYED IN SERIAL MONITOR

The figure shows the output of the proposed garbage management system the value read from the sensor will be displayed in the serial monitor. This data is then send transferred to the ThingSpeak. This figure shows the sensor's reading, status of the Wi-Fi connection, the IP address of the cloud used and the SSID of the network to which is connected the Node MCU ESP Wi-Fi module.

FIG.9 ThingSpeak Field Chart

This figure shows the field chart which is plotted with the information obtained from the sensors. This chart shows the status of the garbage and the person who monitors the account must be given the prior information about the threshold values of the particular dustbins.

CONCLUSION:

This system is mainly developed to monitor the garbage bins for increasing the healthy environment of the smart cities. Smart containers are developed using ultrasonic sensors for detection. The main aim is to maintain the level of cleanliness in the city and form an environment which is better for living. By using this system we can constantly check the level of the garbage in the dustbins which are placed in various parts of the city. If a particular dustbin has reached the maximum level then the employees can be informed and they can immediately take certain actions to empty it as soon as possible. The employees in the control room can check the status of these bins anytime and inform to the concern workers. This can prove to be a very useful system if used properly. The system can be used as a benchmark by the people who are willing to take one step further for increasing the cleanliness in their respected areas. The proposed system is checked in a small area and it can be used in all the big areas. As this system also reduces manual work certain changes can be done in the system to take it to another level and make it more useful for the employees and people who are using it. This system is much smaller in size. Since Node MCU is used, the size of the system gets reduced to a greater extent and the system is also cost effective.

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